Application No. 10/646,927

IN THE SPECIFICATION:

Please amend the specification as follows.

Paragraph beginning on page 13, at prenumbered line 13, has been amended as follows:

Referring now to Fig. 1 and 2, the simplified side view and top view drawings of a shutter type VOA and crossbar optical switch are disclosed by prior arts, see for example, W. Noell, et al., "Applications of SOI-Based Optical MEMS", IEEE J. on Selected Topics in Quantum Electronics, Vol. 8, No. 1, Jan/Feb 2002, pp.148-154; C. Marxer, et al., " A Variable Optical Attenuator Based on Silicon Micromechanics", IEEE Photonics Technol. Lett., Vol. 11, No. 2, 1999, pp. 233-235; C. Marxer and N.F. de Rooij, " Micro-Opto-Mechanical 2x2 Switch for Single-Mode Fibers Based on Plasma-Etched Silicon Mirror and Electrostatic Actuation", IEEE J. of Lightwave Technology, vol. 17, No. 1, 1999, pp.2-8; W. -H. Juan and S. W. Pang, " High-Aspect-Ratio Si Vertical Micromirror Arrays for Optical Switching", IEEE J. Microelectromechanical Systems Vol. 7, No. 2, 1998, pp.207-213. These disclosed micro-optical devices for VOA and optical switch applications may be made in accordance with various known fabrication processes. In a particular process, the micro-optical devices 100 are made on substrates ~~110~~ such as, the commercially available silicon-on-insulator (SOI) wafers. The SOI wafer includes a single crystal silicon device layer on a single crystal silicon handle wafer with a normally less than 2 micrometers thick SiO2 insulator layer. The ~~micro-optical devices 100~~ micro-optical devices 100 comprise a reflective movable ~~micro-mirror~~ micro-mirror 113 on a ~~shuttle beam~~ shuttle beam 121, a set of ~~suspended springs~~ suspended springs 123a, 123b connected with the ~~shuttle beam~~ shuttle beam 121 and anchored on to substrate 116 via anchors 120a-120d, a set of ~~movable comb drive electrodes movable comb drive electrodes~~ movable comb drive electrodes 122 that is connected with movable ~~shuttle beam~~ shuttle beam 121 and said ~~suspended springs~~ suspended springs 123a, 123b move toward a set of ~~stationary comb drive electrodes~~ stationary comb drive electrodes 117 a, b, c due to the electrostatic force between said two sets of comb drive electrodes when the electrical load is applied to the comb drive actuator, and a set of ~~fiber optics~~ fiber optics 111, 112 for handling

the ~~input and output optical signals~~ input and output optical signals 114, 115, respectively. These features and microstructures of ~~micro-optical devices 100~~ micro-optical devices 100 are formed in the device layer of SOI wafer via using the deep-reactive-ion-etching (DRIE) process, then a hydrofluoric acid (HF) etch process is used to remove the oxide underneath portions of the micro-optical device movable in relation to the base or substrate, such as the ~~micro-mirror~~ micro-mirror 113, ~~shuttle beam~~ shuttle beam 121, ~~suspended springs~~ suspended springs 123a, 123b, ~~movable comb drive electrodes~~ movable comb drive electrodes 122, etc. Process induced feature size deviations may lead to the side instability regarding to the electrostatic force unbalance between electrode fingers 119 of ~~movable comb drive electrodes~~ movable comb drive electrodes 122 and electrode fingers 118 of ~~stationary comb drive electrodes~~ stationary comb drive electrodes 117 a, b, c. The misalignment and improper treatment during the photolithography, and the side wall etching effect during the DRIE process may cause the phenomena of that comb feature size deviated from the designed and planed layout.

Paragraph beginning on page 19, at prenumbered line 14, has been amended as follows:

To make the folded-beam spring 311 become thinner as thinned folded-beam spring 312 shown in Fig. 3, we can apply the process shown in Fig. 4 to fabricate the micro-optical device 310 with thinned spring structure 312. After the first lithography step, SiO_2 hard mask 412 is patterned to be the shapes of the comb electrodes, shutter, and anchors on silicon device layer 413 of SOI wafer 411 (Fig. 4a ~ 4b) wherein the SOI wafer 411 includes an isolation SiO_2 layer 414 embedded between a device layer 413 and a handle wafer 415. The photo resist (PR) mask 416 is defined thereafter to be the shape of folded-beam spring (Fig. 4c). By using deep reactive ion etching (DRIE) to etch this SOI wafer with said SiO_2 hard mask 412 and photo resist mask 416 on surface, the PR mask will be fully etched away after silicon of no mask area being etched down to certain depth. Then the area of folded-beam spring begins to be etched. Since the Si/PR etching selectivity is approximately 10 ~ 40 during typical DRIE process. The DRIE process is done when the insulation SiO_2 layer underneath the silicon device layer is reached during the etching process

(Fig. 4e). The movable comb fingers, shutter, and suspended thinned spring are eventually released by <u>using</u> HF wet etching <u>to remove the insulation SiO_2 layer 414 underneath the relative area</u> (Fig. 4f). A step height between folded-beam spring and comb finger electrodes can be made to form a micro-optical device 310 with stepped structures.

Paragraph beginning on page 20, at prenumbered line 9, has been amended as follows:

To further explain and prove our invention, ~~We~~ <u>we</u> made comb drives of 4 types of springs, they were comb drives of 3-folded normal spring, 3-folded thinned spring, 2-folded normal spring, and 2-folded thinned spring. The related geometric parameters of these springs are spring length of 800mm, spring width of 2.3 mm, spring thickness of 92mm, comb finger gap of 4mm, comb finger number of 100, comb finger overlap of 20mm, and comb finger thickness of 45mm. Comparing measured data with the simulated curves of displacement versus square of applied voltage as shown in Fig. 5, the 3-folded thinned spring comb drive can be actuated by a relatively lowest driving voltage. This result points out that the comb drive of 3-folded thinned spring exhibits the best-optimized performance, i.e., the larger displacement under the same applied voltage, and the longest displacement without happening side sticking of comb finger electrodes. It proved our invention may lead to comb drive actuators have higher stiffness in perpendicular direction, i.e., the y-direction, to moving direction and lower spring force in the moving direction i.e., the x-direction. Without making springs of longer length, it means larger occupation area and lower process yield, we can have voltage reduction by just making the spring thinner. Beside, according to present process design, this thinned spring structure is defined and patterned by one mask only. It means no physical parameter deviation occurred due to the process, like misalignment induced variation of spring width, etc. The above experimental results have been disclosed by inventors in these papers (Chihchung Chen, Chengkuo Lee, Yenjyh Lai, and Wen-Chih Chen, "Study of Lateral Comb Drive Actuator with Large Displacement and Low Actuation Voltage," *Proc. of Microprocesses and Nanotechnology 2002,* pp.304-305, Tokyo, Japan, Nov. 6-8, 2002, IEEE Catalog No. 02EX589.; and Chihchung Chen,

Chengkuo Lee, Yenjyh Lai, and Wen-Chih Chen, "Development and Application of Lateral Comb-drive Actuator," Jpn. J. Appl. Phys. Vol. 42, Part.1, No. 6B, 2003, pp.4059-4062).

Paragraph beginning on page 21, at prenumbered line 14, has been amended as follows:

~~In according~~ According to another aspect of our invention, the micro-optical devices 100 shown in Fig. 1 or micro-optical devices 310 shown in Fig. 3 can be modified into the layout configuration shown in Fig. 6. To further reduce the instability influence from the moment contributed by the lateral electrostatic force of comb electrodes, all the spring anchors are assigned symmetrically at both sides of comb electrodes. By using such symmetric layout in conjunction with our spring thinning approach, we are able to make the comb drive actuator exhibit enlarged displacement and robustness to instability.

Please insert the following NEW paragraph on page 21, between prenumbered lines 21 and 22:

The micro-optical device 611 that is disclosed in the present invention as shown in Fig. 6 comprises a reflective mirror 617 on one side of a shuttle beam 616, a set of suspended springs 615a, 615b which supports the shuttle beam 616 at their free ends and fixed onto a substrate via anchors 612b, 612c, a set of movable comb drive electrodes 614 that is connected with said shuttle beam 616 on one side and a set of suspended springs 615c, 615d on the other side, and a set of stationary comb drive electrodes 613. The shuttle beam 616 is arranged at the center of whole device structure and free-standing supported by four suspended symmetric normal folded-beam springs 615a, 615b, 615c, and 615d, where these four springs are symmetric allocated on both sides of comb drive electrodes 613, 614, and suspended springs 615c and 615d are fixed onto the substrate via rigid anchor structure 612a. These symmetric normal folded-beam springs may also denote as the symmetric parallel springs. The set of stationary comb drive electrodes 613 is electrically isolated from all the rest parts of micro-optical device 611, e.g. the set of movable comb drive electrodes 614. When electrical voltage bias is applied across

the comb drive electrodes 613 and 614, the generated electrostatic force will drive the comb drive electrodes 614 and the whole movable part of micro-optical device 611 toward the stationary comb drive electrodes 613. When we apply said micro-optical device 611 in optical MEMS applications, a straight line light path 618 formed by an incoming light from an input optical fiber 619 to a reception optical fiber 620 and a shutter type mirror of said mirror 617 will compose a typical device configuration for gate type optical switches and variable optical attenuators. Thus the position of said mirror 617 will be away from its rest position, when an electrical voltage is applied between comb drive electrodes 613 and 614. According to different spatial position of mirror 617 and light path 618 with respect to different applied voltages, the intensity of light in transmission will vary away from the original incoming light intensity. More importantly, we can deploy the technology disclosed in the first embodiment regarding to Fig. 3 and Fig. 4 to prepare a micro-optical device 611 with said symmetric normal folded-beam springs 615a, 615b, 615c and 615d thinner than the comb drive electrodes 613 and 614 in the perpendicular direction to substrate. Therefore the spring stiffness becomes higher in the planar direction along with the direction perpendicular to shuttle beam 616 moving direction.

Paragraph beginning on page 24, at prenumbered line 11, has been amended as follows:

With the background understanding, in order to compare the difference regarding to compressive and normal ~~springs~~ springs, we propose three new designs of comb drive actuators. Similar to the symmetric normal folded-beam springs ~~615a to 615d~~ 615a, 615b, 615c and 615d on both sides as shown in Fig. 6, we design new comb drives with symmetric compressive folded-beam springs ~~715a to 715d~~ 715a, 715b, 715c and 715d on both sides, as shown in Fig. 7, and new comb drives with asymmetric folded-beam springs ~~layout~~ 815a, 815b, 816a and 816b on both sides, ~~but~~ where one is the compressive spring (815a and 815b) and the other is the normal spring (816a and 816b), as shown in Fig. 8a.

The symmetric compressive folded-beam springs also denote as symmetric compressive springs, while the asymmetric folded-beam springs denote as

asymmetric hybrid springs too. Except to the replacement of suspended springs from the format of 615a, 615b, 615c and 615d in Fig. 6 to the format of 715a, 715b, 715c and 715d in Fig. 7, all the rest structures and elements in the micro-optical device 711 as shown in Fig. 7 represent identical functions as the structures and elements explained in Fig. 6. As a result, the micro-optical device 711 comprises a reflective mirror 717 on one side of a shuttle beam 716, a set of stationary comb drive electrodes 713a and 713b, a set of movable comb electrodes 714, and four suspended symmetric compressive folded-beam springs 715a, 715b, 715c and 715d. The suspended compressive folded-beam springs 715a, 715b are connected with shuttle beam 716 and anchored onto the substrate via anchors 712b and 712c. The rest part of suspended compressive folded-beam springs 715c and 715d are connected with shuttle beam 716 via a set of movable comb drive electrodes 714, and springs 715c and 715d are fixed onto the substrate via anchor 712a. The light signals from input optical fiber 719 transmit to reception optical fiber 720 so as to form a light path 718. As we disclosed in previous paragraphs regarding to Fig. 6, the micro-optical device 711 can perform the gate switch and light attenuation functions in conjunction with light path arrangement as shown in Fig. 7.

Additionally, the Fig. 8a discloses another kind of spring design of present invented device. We replace the design of suspended springs from the format of 615a, 615b, 615c and 615d in Fig. 6 to the format of 815a, 815b, 816a and 816b in Fig. 8a. All the structures and elements other than the asymmetric hybrid springs 815a, 815b, 816a and 816b of the micro-optical device 811 as shown in Fig. 8a represent identical functions as the structures and elements explained in Fig. 6. Again, the micro-optical device 811 comprises a reflective mirror 817 on one side of a shuttle beam 821, a set of stationary comb drive electrodes 813a and 813b, a set of movable comb electrodes 814, and four suspended asymmetric hybrid springs 815a, 815b, 816a and 816b. In particular, the compressive folded-beam springs 815a, 815b among the suspended asymmetric hybrid springs are connected with shuttle beam 821 and anchored onto the substrate via anchors 812b and 812c, while the rest part of the asymmetric hybrid springs 816a and 816b on the other side of device 811 are connected with shuttle beam 821 via a set of movable comb drive electrodes 814, and springs 816a and 816b are fixed onto the substrate via anchor

812a. The light signals from input optical fiber 819 transmit to reception optical fiber 820 so as to form a light path 818. As we disclosed in previous paragraphs regarding to Fig. 6 and Fig. 7, the micro-optical device 811 can perform the gate switch and light attenuation functions in conjunction with light path arrangement as shown in Fig. 8a.

Based on the analytical model, and FEM analysis results via ANSYS, we may derive the curves of k_y and k_{ey} versus the travel distance in x-direction, as shown in Fig. 9. It presents the k_y of comb drive with symmetric parallel folded-beams spring decreased rapidly and the value of k_y coincides with the k_{ey} at 32 μm travel distance. Regarding to the comb drive with compressive folded-beams springs, in spite of that the k_y of comb drive with a pair of compressive springs is increased as spring being compressed, the k_y still coincide with the k_{ey} at 18 μm displacement. Because the initial k_y of this type comb is too small. To further enhance the lateral stiffness in y-direction of comb-drive with compressive beam spring design over initial actuation period, one pair of the compressive beam springs is replaced by a pair of normal folded-beam spring, and then this is denoted as a comb drive with asymmetric hybrid springs, as shown in Fig. 8a. Therefore the micro-optical device using this comb drive actuator comprises a pair of normal folded-beam spring 816a and 816b on one side, and a pair of compressive beam springs 815a and 815b on the other side. However, this third type comb drive actuator exhibits a decreased k_y regarding to increment of x-directional displacement. To strengthen the lateral stiffness of this asymmetric spring comb again, we proposed an U-shaped-bridge joint 862 to connect the pair of parallel normal folded-beams springs to enable a new comb drive actuator based on asymmetric hybrid springs with U-shaped-bridge joint 862 comprises a pair of normal folded-beam spring 856a and 856b with an U-shaped-bridge joint 862 on one side, and a pair of compressive beam springs 855a and 855b on the other side, as shown in Fig. 8b.

In order to let the readers to have better understanding about another new design of springs of present disclosed micro-optical device, we hereby explain the notation of all the structures and elements shown in Fig. 8b. Although, there is only the design difference of suspended folded-beam springs, i.e., 855a, 855b, 856a, 856b and 862 among the device configuration as shown in Fig. 8b and device

configurations discussed in Fig. 6, Fig. 7 and Fig. 8a. All the structures and elements other than the asymmetric hybrid springs 855a, 855b, and 856a and 856b with a U-shaped-bridge joint 862 of the micro-optical device 851 as shown in Fig. 8b represent the same functions as the structures and elements shown in Fig. 6, Fig. 7, and Fig. 8a, and discussed in related paragraphs. Basically, the micro-optical device 851 comprises a reflective mirror 857 on one side of a shuttle beam 861, a set of stationary comb drive electrodes 853a and 853b, a set of movable comb electrodes 854, and four suspended asymmetric hybrid springs 855a, 855b, and 856a and 856b with a U-shaped-bridge joint 862. In particular, the compressive folded-beam springs 855a, 855b among the suspended asymmetric hybrid springs are connected with shuttle beam 861 and anchored onto the substrate via anchors 852b and 852c, while the rest part of the asymmetric hybrid springs 856a and 856b on the other side of device 851 are connected with shuttle beam 861 via a set of movable comb drive electrodes 854. Additionally springs 856a and 856b are fixed onto the substrate via anchor 852a, and there is a U-shaped-bridge joint 862 to connect springs 856a and 856b as shown in Fig. 8b. The light signals from input optical fiber 859 transmit to reception optical fiber 860 so as to form a light path 858. As we disclosed in previous paragraphs regarding to Fig. 6, Fig. 7 and Fig. 8a, the micro-optical device 851 is able to perform the gate switch and light attenuation functions in conjunction with light path arrangement as shown in Fig. 8b.

As shown in Fig.9, similarly, the initial k_y of this type has been apparently promoted by such modification, the k_y keeps increasing as the displacement increasing as the same trend observed in the case of four compressive folded-beam springs. As a result, the k_y of the asymmetric comb drive actuator with U-shaped-bridge joint 862 meets with the k_e at x-directional travel distance of 58μm approximately. By using our innovative design, we are able to increase the maximum static displacement performance about 81% in this case.

Please insert the following NEW paragraph on page 26, between prenumbered lines 11 and 12:

More importantly, we can simply deploy the technology disclosed in the first embodiment regarding to Fig. 3 and Fig. 4 to prepare micro-optical devices of 711, 811, and 851 with thinned springs with respect to comb drive electrodes in the perpendicular direction to substrate. Thereafter the spring stiffness is further increased in the planar direction along with the direction perpendicular to moving direction of shuttle beam.

Paragraph beginning on page 26, at prenumbered line 18, has been amended as follows:

In according to the other aspect of our invention, we proposed micro-optical devices using comb drive actuator 1050 ~~with~~ based on a stationary comb finger ~~electrodes~~ electrode of a shape with oblique angle 1051, and a movable comb finger electrode of a shape with oblique angle 1052, as shown in Fig. 10b. Thereby the force output from said comb drive actuator is enlarged based on this approach. Basically the generated electrostatic force from the comb drive actuator is contributed by the electrostatic field between the two comb finger electrodes.

The displacement of the movable comb finger electrode 1052 from its original rest position is a result of force balance between the electrostatic force and spring restoration forces along with the travel direction and perpendicular direction of travel direction, i.e., denoted as spring force 1004 and spring force 1003. The spring design mentioned in present embodiment is one of our inventions disclosed in embodiments 1 and 2.

Comparing to the electrode shape of conventional comb finger 1001 and 1002 as shown in Fig. 10a, the major field line is aligned much closed to the moving locus, which means better energy coupling efficiency can be obtained. Therefore, under the same input voltage, the force generated by comb drive of oblique shape comb finger electrode (1050) is larger than the conventional comb drive actuator 1000. The relative experimental results have been disclosed by the following literatures, see for example, M. A. Rosa, S. Dimitrijev, and H. B. Harrison, “Enhanced electronic force generation capability of angled comb finger design used

in electrostatic comb-drive actuators," Electronics Letters, 1998, Vol.34, No. 18, pp.1787~1788; J. Hsieh, C.-C. Chu, and W. Fang, "On the driving mechanism design for large amplitude electrostatic actuation," Proceedings of 2001 ASME International Mechanical Engineering Congress and Exposition, paper number of IMECE2001/MEMS-23804, Nov. 11~16, 2001, New York, USA. These publications have proven the basic idea regarding to comb drive of oblique shape comb finger electrode. To the best knowledge of inventors', there is no published works regarding to the micro-optical devices using comb drive actuator with comb finger electrode of oblique shape. Thereby micro-optical devices using this new comb drive actuator are suitable for device designs and applications need large actuation force. In conjunction with spring with higher stiffness, the micro-optical devices using this new comb drive actuator can generate larger actuation force against to the spring force ad side instability effect, thereby reaching larger x-directional displacement.

Paragraph beginning on page 32, at prenumbered line 6, has been amended as follows:

On the other hand, regarding to the micro-optical devices as shown in Fig. 11b, we may integrated or assembled a plurality of reflective micro-mirror together with multiple input and output channels in a device configuration that the micro-mirrors 1151 and 1152 of said micro-optical device are located and aligned in a geometric layout configuration where the input light beam from the transmission fiber 1155 of one of input channels reflected by said micro-mirror 1151 toward another reflective micro-mirror 1152 then being reflected again and transmitted forward to the reception fiber 1156 of the output channels; thereby the input optical signals according to light path 1153 from the input fiber 1155 is reflected by multiple micro-mirrors 1151, 1152, etc. regarding to various spatial position at micro-mirror position 1151a, b and 1152a, b toward ~~the~~ the reception fiber 1156 of the output channels. As a result, ~~By~~ by maintaining the micro-mirror 1151 at mirror position 1151a, we may adjust the mirror position regarding to another micro-mirror 1152 from 1154a position to 1154b position. Moreover, our approach may have broaden adjustable range of light path, say from 1153 input light path to 1154a, 1154b, and 1154c output light path, by using more than one movable reflective micro-mirrors to change the

reflected light path. By doing so, we may apply said micro-optical devices for optical switching and variable optical attenuation applications in multiple channels manner, while the good optical performance can be achieved based on our proposed new comb drive actuator designs.

More importantly, said micro-optical devices discussed in present embodiment are the devices comprise comb drive actuators to drive the mirrors 1111, 1151 and 1152 to change their locations regarding to various light path configurations, where these comb drive actuators deploy the springs using the designs of said springs disclosed in previous embodiments. Besides, the comb drive actuator 1050 with finger electrodes of oblique angle shape as disclosed in the third embodiment can be applied to provide the necessary force to move said mirrors 1111, 1151 and 1152 in present embodiment, thereby the required driving voltage is reduced.

Part of this invention has been disclosed in the literatures of: Interactive multimedia materials shown in : Chihchung Chen, Chengkuo Lee, and Yen-jyh Lai "Novel VOA Using In-Plane Reflective Micromirror and Off-Axis Light Attenuation", IEEE Communications Mag., the quarterly supplement IEEE Optical Communications, pp. S16-S20, Aug. 2003., [http://www.comsoc.org/ci1/Public/2003/aug/index.html].

Paragraph beginning on page 34, at prenumbered line 10, has been amended as follows:

Regarding to our invention, we propose a new latch, i.e., a clip type latch, mechanism for said micro-optical devices in an analog controllable manner. As shown in shown in Fig. ~~12a,~~ 12-a, a clip type latch mechanism comprises a grip structure 1202 formed on a substrate of said micro-optical device to clamp said shuttle beam 1206 via the friction force forming at the contact interface of the clamped location between grip structure 1202 and shuttle beam 1206; thereby said micro-optical device can maintain its status at states with respect to various micro-mirror 1207 positions and locations in an analog controllable manner without electrical power consumption when said clip type latch is used to clamp said shuttle beam 1206. The grip structure 1202 can be moved by various micro-actuators 1203.

To move and control the micro-mirror 1207 to the desired position is done by the ~~micro-actuators and suspended springs 1201 of said micro-optical device.~~ the force balance between the electrostatic force from the comb drive actuators 1201 and suspended springs 1204 of said micro-optical device, where these suspended spring 1204 are fixed onto substrate via anchors 1205. The suspended springs 1204 are said springs of our inventions disclosed in previous embodiments. Besides, the comb drive actuators 1201 can further deploy our advanced design of comb drive actuator 1050 with finger electrodes of oblique angle shape as disclosed in the third embodiment so as to reduce the required driving voltage. When the micro-mirror 1207 is moved to said desired position already, we can apply the grip structure 1202 to clamp the shuttle beam 1206. Thereafter, without continuously ~~apply~~ applying electrical load to said micro-optical device, we may hold said micro-mirror 1207 at desired position with electrical power consumption. As shown in Fig. 12b, the control of grip structure 1252 can also be realized by a micro-actuator 1253, ~~in stead~~ instead of two micro-actuators 1203 for individually controlling the grip structure 1202 shown in Fig. 12a.

As shown in Fig. 12b, the location of micro-mirror 1207 is controlled by the force balance between the electrostatic force from the comb drive actuators 1251 and suspended springs 1254 of said micro-optical device, where these suspended spring 1254 are fixed onto substrate via anchors 1255. The suspended springs 1254 are said springs of our inventions disclosed in previous embodiments. Additionally, the comb drive actuators 1251 can further deploy our advanced design of comb drive actuator 1050 with finger electrodes of oblique angle shape as disclosed in the third embodiment so as to reduce the required driving voltage. Again, when the micro-mirror 1257 is moved to said desired position, then we apply the grip structure 1252 to clamp the shuttle beam 1256. Without continuously applying electrical load to said micro-optical device, we hold said micro-mirror 1257 at a particular position with electrical power consumption.

Additionally, if we separate two sides of the grip structure 1202 in Fig. 12a or 1252 in Fig. 12b into two electrical electrodes with a voltage difference, and there is insulation coating on the contacting surface of 1202 and 1252, then the grip arms from two sides of grip structure can move close to each other due to the electrostatic

force, and shuttle beam 1206 in Fig. 12a or 1256 in Fig. 12b will be clamped by these two grip arms 1202 in Fig. 12a or 1252 in Fig. 12b, respectively, due to said electrostatic force. Briefly speaking, clip type latches by using friction force or electrostatic force are invented for said micro-optical devices to maintain the status of said micro-optical devices at certain condition without power consumption in an analog control manner.